

Run 6 - Heavy Ions

Preparations and Run Organizations
What are the likely choices?
Can we do better?



Prep Work before (any) run

answer open questions:

- when do we start up?
- how many weeks do we run?
- do we combine the two fiscal years?
- what species do we run?
- do we run heavy ions (or any ions) at all?

cool down (no changes to last year)

both rings will be warmed up to room temperature

- | | |
|-----------------------------------|---------------------------------|
| ✖ Cool-down warm→80 K | ~ 30 days |
| ✖ Cool-down 80K to 4K | ~ 10 days |
| ✖ Set-up with ions | 2-4 weeks |
| ✖ Ramp-up | 2 weeks (→collisions overnight) |
| ✖ Physics (+ luminosity increase) | ? weeks |

Options

- ✖ assume that we will start with a long pp run
 - two modes: HI follow pp in FY06
 - one mode: no HI in 06, dedicated HI run in FY07
- ✖ Au-Au
 - low energy run (60 GeV)
 - wanted by PHENIX (?)
- ✖ d-Au (or Au-d)
 - more statistics than the 1st run
 - wanted by BRAHMS and STAR (what about PHENIX?)
- ✖ light ions
 - even lighter ions (Si-Si)?
 - depends on Cu-Cu results

Shutdown activities & Improvements

✖ Collimators

- no additional collimators planned
- added vertical collimators were not useful
- need software update (working on feedback) to reduce time

✖ BPMs

- all tunnel BPMs are moved into alcoves
- 6:00 and 8:00 modules have relays removed -> plan to do as many more as possible
- 50 planes are reversed in software at present
- moving the timing of the DX BPMs into the abort gap caused other problems -> undone

✖ shielding?

- there is not enough time for a significant shielding of another IR (STAR?)

✖ stochastic cooling

- stochastic cooling is expected to be available in the yellow ring only - after several weeks of commissioning with beam

✖ vacuum

- PHOBOS will be replaced by a normal pipe with NEG coating ☺
- 150 m NEG coating this year, 100 m more next year. More pumping in cold bore.

✖ abort system/BLAM

- improved BLAM software could help to reduce set-up time (exclude BLMs under fences from analysis)
- prefires only expected to be a problem if we run 100 GeV Au or 250 GeV pp

RHIC Run organization

- ✗ Run Coordinator PP Ptitsyn
- ✗ Run Coordinator HI Drees
- ✗ Scheduling physicist (TBD)
- ✗ RHIC shift leaders: Bai, (Drees), Huang, Luo, Montag, (Ptitsyn), Satogata, Pilat, Kewisch, ?
- ✗ Back-up RHIC shift leaders: Fischer, Ptitsyn/Drees, Trbojevic, scheduling physicist
- ✗ Operations + RHIC specialist (Marr) → larger role during set-up, ramp-up, beam-ex
- ✗ should operations be involved more and AP less? Was the role of operations improved last run? Did we do better? Were we more efficient?

Weekly schedule:

Monday	Scheduling meeting
Monday	RHIC Weekly meeting
Tuesday	Time Meeting & Machine-experiments meeting
?	Beam Experiments
?	maintenance day (every 3 weeks?)
daily	RHIC run meeting

Machine Set-up and Ramp-up

- ✘ Can Tandem begin working on LI, HI or d behind pp stores?
- ✘ setup depends on 2 modes or 1 mode
 - two modes: no dry run (already running pp), or operation with 1 beam, no ps check-out etc.
 - one mode: special needs will result from next shutdown and changes to the machine -> next retreat ;)
- ✘ Generally the goal of early collisions for experiments (over night)

Physics running

- ✖ Start of physics running

mutual interest in early start of regular stores/operations
guidelines for start of physics: adequate collisions,
rebucketing, collimation in place

mutual decision to define physics start-up

- ✖ Development: day shifts, 8am-4pm, after agreement or approval by experiments/scheduling physicist

- ✖ Beam experiments: 12 hours/week

- ✖ accesses: 3 week maintenance schedule preferred, 'cluster' with beam experiments, any other access: scheduling physicist (accumulate access requests, review ...)

- ✖ End of store procedure - fixed length stores - end of store determined by MCR→countdown for experiments (automated in BERT?)

Planned upgrades for the next few years

For FY2005	For FY2006	For FY2007	For FY2008
RHIC injectors			
AGS cold helical snake		New OPPIS solenoid	EBIS test
RHIC luminosity and background			
Collimation system, vertical	Transverse damper system		
Vacuum upgrade BRAHMS	Vacuum upgrade PHOBOS		
Vacuum upgrade STAR	Vacuum upgrade PHENIX		
NEG pipes (200 m)	NEG pipes (300 m)		
	Solenoids?		
Stochastic cooling test	Stochastic cooling test	Stochastic cooling	
RHIC time in store			
FEC PS replacement	FEC PS replacement	FEC PS replacement	
QLI reduction	QLI reduction	QLI reduction	
All BPM electronics to alcoves	BPM system upgrade	Injection set-up	
BPM system upgrade	Injection set-up		
Gradient error correction	Decoupling (ramp)		
Tune feed-forward (ramp)			
Decoupling (ramp and store)			
Corrector PS reliability			
Faster down-ramps			
Injection set-up			
Unroll one triplet, vibration test			

yellow available in FY06?

Run Projections for future AuAu runs

(from C-AD document)

Fiscal year		2002A	2004A	2005E	2006E	2007E	2008E
No of bunches	...	55	45	45	78	88	112
Ions/bunch, initial	10^9	0.6	1.1	1.1	1.1	1.1	1.1
Average beam current/ring	mA	33	49	49	85	96	122
β^*	m	1	1	1	1	1	1
Peak luminosity	$10^{26} \text{ cm}^{-2} \text{ s}^{-1}$	5	15	15	25	28	36
Average store luminosity	$10^{26} \text{ cm}^{-2} \text{ s}^{-1}$	1.5	4.0	4.7	6.3	7.1	9.0
Time in store	%	25	53	56	58	59	60
Maximum luminosity/week	μb^{-1}	25	160	159	220	253	327
Minimum luminosity/week	μb^{-1}			160	160	160	160
Maximum integrated luminosity	μb^{-1}	89	1370	1430	1980	2280	2940
Minimum integrated luminosity	μb^{-1}			1440	1440	1440	1440

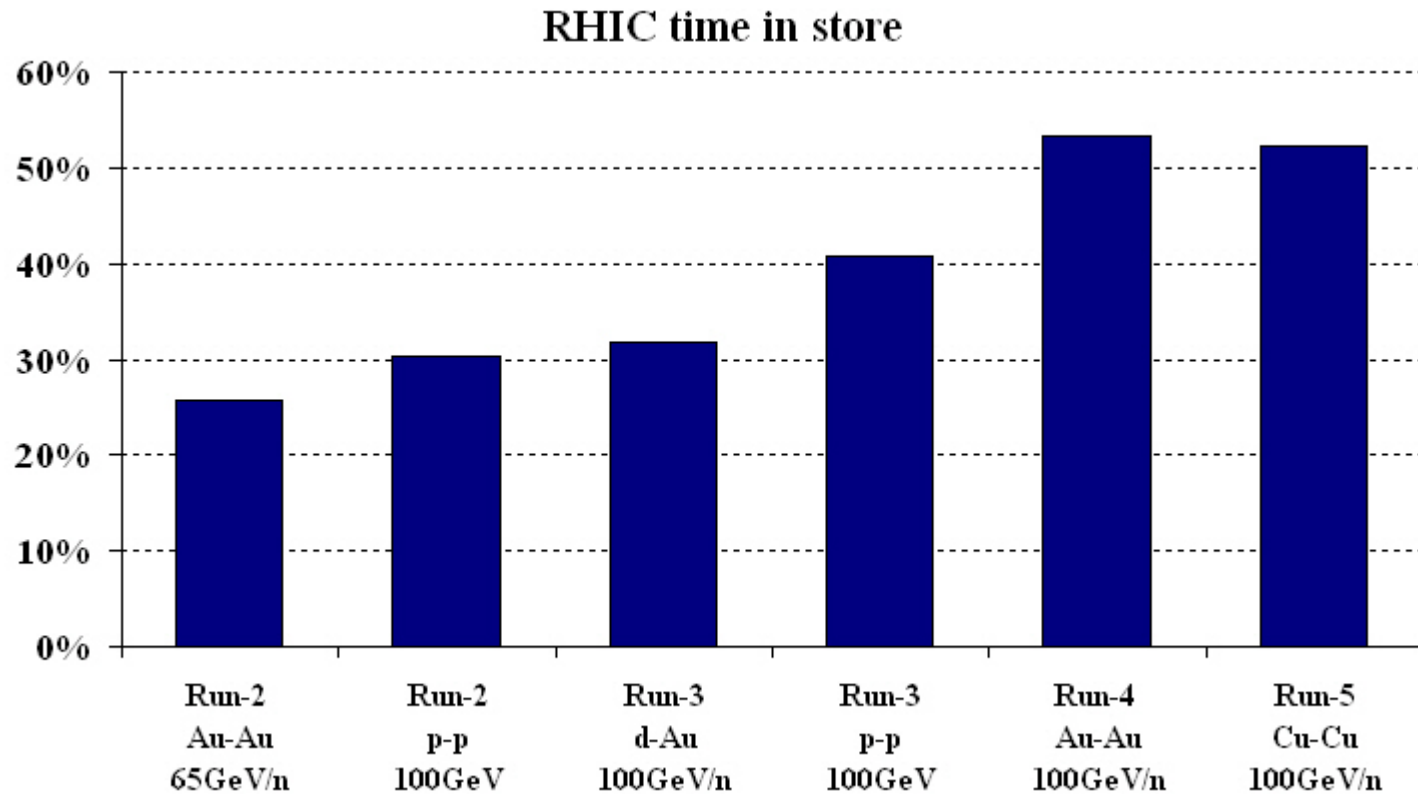
note:

β^* of less than 1 m not included

time in store seems to be already “saturated” (?)

2008E based on stochastic cooling in both rings

RHIC performance projections



Au-Au run – who wants one?

Table 2.11: Physics yields from the PHENIX run plan for 27 cryo weeks per year

Run	Species	$\sqrt{s_{NN}}$ (GeV)	Physics Weeks	$\int \mathcal{L} dt$ (record.)	J/ψ 's N. Arm	$\pi^0 p_T^{max}$ $A_{LL}(\pi^0) p_T^{max}$ (GeV/c)
	(GeV/c)	(GeV/c)				
4	Au+Au	200	14	$123 \mu b^{-1}$	1640	17.8
	p+p	200	0			
5	Si+Si	200	9	$2.2 nb^{-1}$	1570	15.8
	p+p	200	5	$1.2 pb^{-1}$	1860	15.1
6	Au+Au	62.4	19	$45 \mu b^{-1}$	120	10.4
7	p+p	200	19	$62 pb^{-1}$	98,600	24.3
8	Au+Au	200	19	$841 \mu b^{-1}$	11,200	22.5
9	p+p	500	19	$211 pb^{-1}$	944,000	39.1
10	d+Au	62.4	19	$1.3 nb^{-1}$	102	9.0

✖ PHENIX

from decadal plan, Nov. 2003

- decadal plan states a 62 GeV low energy run of Au-Au (19 weeks)
- outdated?
- there is no significant difference to the 37 week plan (add 2 weeks of pp @ 500 GeV)

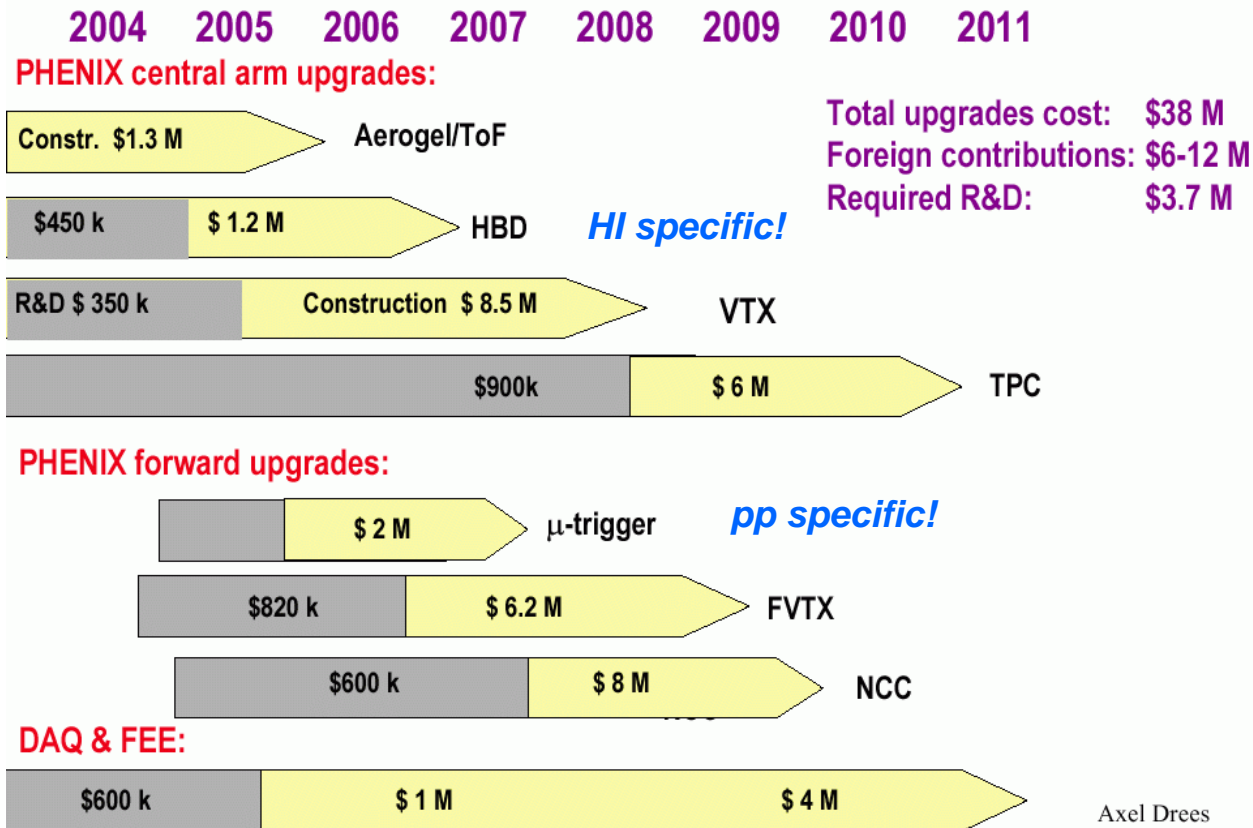
PHENIX decadal plan for 37 cryo weeks

Table 2.12: Physics yields from the PHENIX run plan for 37 cryo weeks per year

Run	Species	$\sqrt{s_{NN}}$ (GeV)	Physics Weeks	$\int \mathcal{L} dt$ (record.)	J/ ψ 's N. Arm	π^0 p_T^{max} $A_{LL}(\pi^0)$ p_T^{max} (GeV/c)
4	Au+Au	200	19	203 μb^{-1}	2700	19.0
	p+p	200	5	0.5 pb^{-1}	750	13.5 5.0
5	Si+Si	200	14	4.7 nb^{-1}	3460	17.3
	p+p	200	5	3.8 pb^{-1}	6030	17.3 7.2
6	Au+Au	62.4	19	45 μb^{-1}	120	10.4
	p+p	500	2	2.1 pb^{-1}	9,400	22.4 9.3
7	p+p	200	22	76 pb^{-1}	122,000	24.9 11.2
		62.4	5	2.7 pb^{-1}	880	11.0 4.8
8	Au+Au	200	19	1503 μb^{-1}	20,000	24.1
9	p+p	500	29	377 pb^{-1}	1,700,000	41.9 20.4
10	d+Au	62.4	29	2.3 nb^{-1}	182	9.6

PHENIX upgrades

Time Line for PHENIX Upgrades (Technology Driven)



PHENIX would want to run with the HBD before the VTX detector comes in (additional interaction length!) \Rightarrow another Au-Au run before 2008?

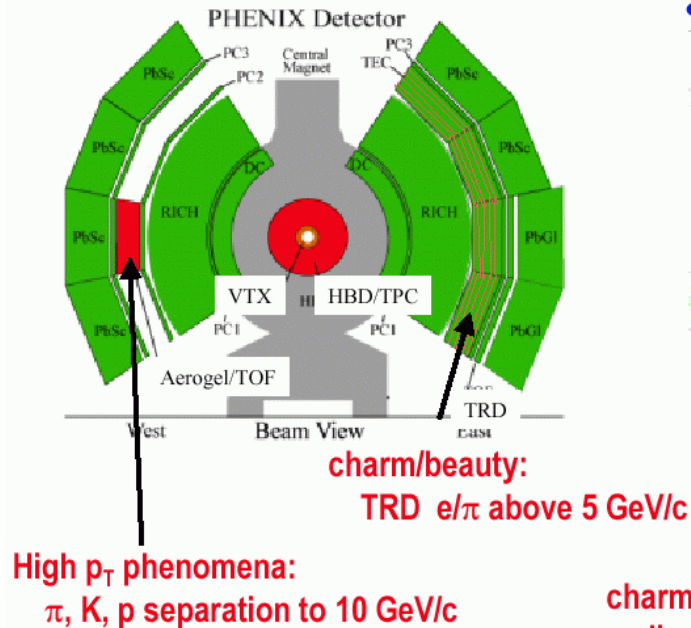
all other upgrades are for all type of runs, AA, pp and pA

PHENIX upgrades

PHENIX Central Arm Upgrades

- **Enhanced Particle ID**

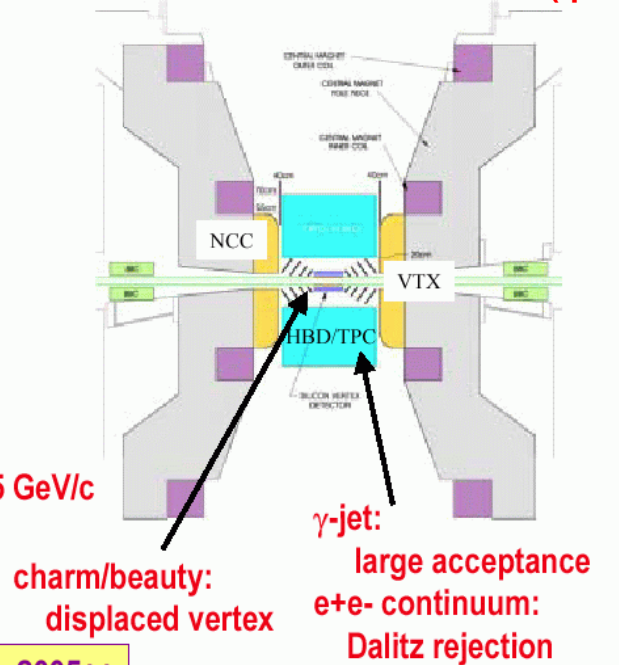
- ✓ **TRD (east)**
- **Aerogel/TOF (2006)**



Staged implementation 2005++

- **Vertex Spectrometer**

- ✓ **flexible magnetic field**
- **VTX: silicon vertex tracker (2008)**
- **HBD (2007) and TPC (2011) (questionable)**



Axel Drees

installation progress for TOF/HBD determines (desired!) startup for next run: early next year?

STAR BUP, NSAC meetg. (June 2004)

T. Hallman

Projected 5 year Beam Use Outlook (STAR Input to BNL Planning Exercise)

Fiscal Year	27 weeks/year BUP (submitted 8/03)		"Optimized Constant Effort" Scenario		32 weeks each year run scenario	
2004	5+14 Au+ Au 200	5+0 pp 200	5+14 Au+ Au 200	5+0 pp 200	5+14 Au+ Au 200	5+0 pp 200
2005	5+9 Au+ Au Escan	5+5 pp 200			6+8 Au+ Au Escan	5+10 pp 200
2006	5+9 d+Au 200	5+5 pp 200	6+11 Au+ Au Escan	5+12 pp 200	5+8 d+Au 200	5+11 pp 200
2007	5+5 Au+ Au 200	5+9 pp 200	5+9 d+Au 200	5+13 pp 200	5+10 Au+ Au 200	5+9 Cu+ Cu 200
2008	5+10 Au+ Au 200	5+5 pp 500	5+15 Au+ Au 200	5+8 Cu+ Cu 200	5+10 Au+ Au 200	5+9 pp 200
$\int \mathcal{L}_{\text{max}} dt$ pp 200	76 pb ⁻¹		88 pb ⁻¹		156 pb ⁻¹	
$\int \mathcal{L}_{\text{max}} dt$ post-TOF Au+Au	1.4 nb ⁻¹		1.6 nb ⁻¹		2.1 nb ⁻¹	
What's missing?	Any Cu+Cu 200; 2 nd +3 rd long pp		2 nd long pp; 2 pp devel. chances		1 pp devel. chance	

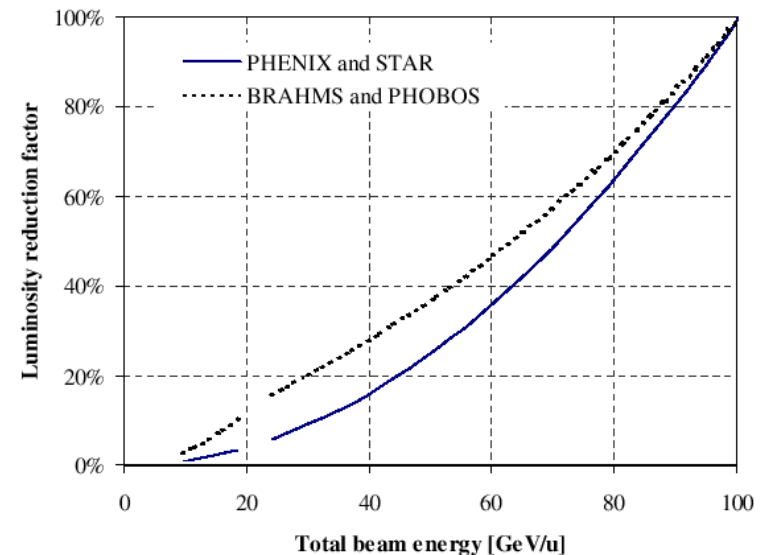
- 32 weeks (vs 27) gives a significant increase in integrated luminosity(!) and allows for timely progress on both the heavy ion and spin physics programs
- Up to 2010, the integrated L for AuAu is $\sim 10 \text{ nb}^{-1}$

STAR had a Au energy scan in the plan for 2005

-> are they still interested? What's their need/plan for upgrades?

Luminosity reduction for low energy running

- ✖ reminder: luminosity is reduced by about $\times 10$ if running at 30 GeV
- ✖ how many weeks would be needed to accumulate the desired integrated luminosity?
- ✖ PHENIX: 19 wks, STAR: 9 wks



STAR upgrade plans/needs for future Au-Au runs (100 GeV)

T. Hallman

Table 1. Prominent aspects of the STAR 10-year physics program, and their needs.

Proposed Measurement	Physics Goal	STAR Upgrades Needed	RHIC L Needed	Open Issues	Proposed Timeline
<u>Heavy Ion Program</u>					
Elliptic flow for hadrons with no light valence quarks	Evidence of partonic collectivity & thermaliz'n	Partial Barrel TOF	2 × present Au+Au	Mean free path of ϕ , J/ψ and Ω in hadronic matter.	2004-7
Upsilon yields and spectra	Temperature and gluon density of partonic matter	EMC completion with preshower	2 × present Au+Au	Is open b production needed in addition to interpret Ψ' yields?	2004-10
Away-side jet suppression vs. E_T and $\Delta\eta$	Quark vs. gluon energy loss in partonic matter	EMC completion	2 × present Au+Au	Measurement of $\Delta\eta$ in the presence of jet quenching.	2004-10
Coherent J/ψ , open charm photoproduction in UPC	Search for strong gluon shadowing in heavy nuclei	EMC completion, μ -vertex	1—2 × present Au+Au	Hadron absorption in nucleus. Cleanliness of open charm signal.	2004-10
Fluctuation/correlation studies with PID	Distinguish QCD dynamical effects on temp. and velocity distrib'ns	Complete Barrel TOF	Present Au+Au	Can different non-statistical effects be unraveled?	2007-2009
Away-side jet fragmentation yields, spectra	Search for effects of chiral and $U_A(1)$ symmetry restoration	Barrel TOF, fast DAQ	2 × present Au+Au	Selectivity for "early" hadrons formed in bulk partonic matter.	2007-9

"Present" = $4 \times 10^{26} \text{ cm}^{-2}\text{sec}^{-1}$ (Run IV AuAu Performance)

Does STAR need any of the listed upgrades available before starting a low energy Au-Au run?

What are their integrated luminosity needs for a 62 GeV run?

2x present Au-Au can be achieved with stochastic cooling in both rings (not available in FY06)

d-Au projections: achieved luminosities vs. estimated

Mode	# bunches	Ions/bunch [10^9]	β^* [m]	Emittance [μm]	$\mathcal{L}_{\text{peak}}$ [$\text{cm}^{-2}\text{s}^{-1}$]	$\mathcal{L}_{\text{store ave}}$ [$\text{cm}^{-2}\text{s}^{-1}$]	$\mathcal{L}_{\text{week}}$
Au-Au	45	1.1	1	15-40	15×10^{26}	4×10^{26}	$160 \mu\text{b}^{-1}$
p \uparrow -p \uparrow *	56	70	1	20	6×10^{30}	4×10^{30}	0.9 pb^{-1}
d-Au	55	110d / 0.7Au	2	15	7×10^{28}	2×10^{28}	4.5 nb^{-1}

* Blue ring polarization of 45%, Yellow ring polarization of 40% in RHIC stores at 100GeV.

note: Cu-Cu estimated luminosities reached – but using different parameters!

Mode	# bunches	Ions/bunch [10^9]	β^* [m]	Emittance [μm]	$\mathcal{L}_{\text{peak}}$ [$\text{cm}^{-2}\text{s}^{-1}$]	$\mathcal{L}_{\text{store ave}}$ [$\text{cm}^{-2}\text{s}^{-1}$]	$\mathcal{L}_{\text{week}}$
Au-Au	45	1.1	1	15-40	15×10^{26}	4×10^{26}	$160 \mu\text{b}^{-1}$
Si-Si	28	14	1	20-35	8×10^{28}	3×10^{28}	6.5 nb^{-1}
Cu-Cu	28	7	1	20-35	3×10^{28}	1×10^{28}	2.5 nb^{-1}
p \uparrow -p \uparrow (I)*	79	100	1	20-30	16×10^{30}	9×10^{30}	3 pb^{-1}
p \uparrow -p \uparrow (II)*	56	150	1	20-30	25×10^{30}	15×10^{30}	4.5 pb^{-1}

*Polarized proton mode (I) assumes that only the warm snake is available in the AGS, and 45% polarization can be reached in RHIC stores. 4 experiments can be served. However, PHOBOS may be unable to run due to electron cloud induced pressure rises in the experiment. Mode (II) assumes that the AGS cold snake has been commissioned successfully, resulting in 50-60% polarization in RHIC stores. Only 2 experiments can be served.

What could make another d-Au run more successful?

T. Satogata

- ✖ improved Au performance (higher bunch intensity), ~ 30%
- ✖ understanding of transverse instabilities
- ✖ emittance blow-up during the ramp, ~50-100%
- ✖ b^* from 2m to 1m?, 50%
- ✖ improved d performance from the beginning (bunch merge in booster), ~20-30%
- ✖ improved time at store compared to FY03, 30% then vs. 50% now, ~20-30%
- ✖ stochastic cooling available in the yellow ring (most likely candidate for the Au-ring)
- ✖ could result in about a factor 2-3 improvement in integrated luminosity
- ✖ what about Au-d run? We'll need some extra time for switching rings (could be done in the same fashion as the 205 pp run)

d-Au: who wants it?

BRAHMS and STAR?

T. Hallman

The STAR Future Scientific Program

Table 1. Prominent aspects of the STAR 10-year physics program, and their needs.

Proposed Measurement	Physics Goal	STAR Upgrades Needed	RHIC L Needed	Open Issues	Proposed Timeline
Proton-Nucleus Program					
Direct photon production in p+A	Map gluon densities in heavy nucleus @ $x < 0.1$	EMC completion	$4 \times$ present d+Au	Background	2006-8

Proposed measurements, scientific motivations, needed upgrades and luminosities, open physics and technical issues and possible (optimistic!) timeline given in full STAR Decadal Plan!

Plan as presentend in the Jun 2004 NSAC meeting
Did it change? What about a different energy?

PHENIX ... d-Au?

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	p+p	200	5	1.2 pb $^{-1}$	1860	15.1
						6.2
6	Au+Au	62.4	19	45 μb^{-1}	120	10.4
7	p+p	200	19	62 pb $^{-1}$	98,600	24.3
						11.0
8	Au+Au	200	19	841 μb^{-1}	11,200	22.5
9	p+p	500	19	211 pb $^{-1}$	944,000	39.1
						19.0
10	d+Au	62.4	19	1.3 nb $^{-1}$	102	9.0

- d-Au was in the decadal plan for 2010 – did that change?
- center-of-mass energy of 62 GeV!

Another light ion run?

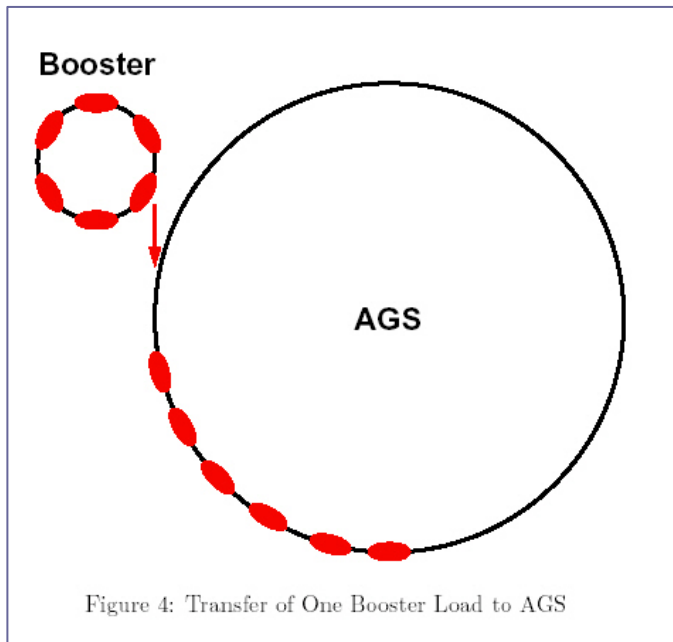
Experience with NSRL: Si, Fe (no changes to last year)

Expected intensities /booster cycle (extraction)

Si 27 $\times 10^9$ <- likely choice?

Fe 13.5 $\times 10^9$ (not really interesting, too close to Cu)

Cu 15 $\times 10^9$ (done, stayed below 7×10^9 this run)



1 booster cycle

→ 1 RHIC bunch with 50% efficiency

Likely better as stripping process

for light(er) ions better than Au

one stage stripping

thinner foils

K. Gardner

Summary

- ✖ everything is still open
 - options (not claiming completeness ;))
 - no HI in FY06 but in FY07
 - d-Au
 - Au-Au at low energy
 - Si-Si (depending on Cu-Cu results?)
- ✖ as always: C-AD needs to know what to run early, experiments need some time to look into data to make a decision (PAC meeting in late summer)
- ✖ all experiments seem (somewhat) interested in d-Au
- ✖ if we run d-Au we think we can do better than in the 1st d-Au run by x2-3